HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTER SYSTEM PROGRAM

INTRODUCTION

This chapter applies to all Fermilab High Efficiency Particulate Air filter systems (HEPA) used as a means of virtual elimination of hazardous airborne particulates such as radioactive, toxic or asbestos contamination in areas of maintenance, cleanup, and routine operations where the possibility for such contamination exists.

DEFINITIONS

<u>Aerosol</u>- a stable suspension of solid or liquid particles in air. (Particle size less than 100 µm)

<u>HEPA filter</u>- a high efficiency particulate air filter is an extended-media dry-type filter with a rigid casing enclosing the full depth of the pleats. The filter shall have a minimum efficiency of 99.97% (from the manufacturer) when tested with an aerosol of essentially monodisperse 0.3 µm particles.

<u>HEPA vacuum cleaner</u>- a vacuum cleaner containing a HEPA filter for removal of contamination.

<u>In-Place HEPA system</u>- a fixed non-portable system for removal of airborne particulates.

<u>In-Place leak test</u>- a method of challenging a HEPA filter system (with filter in place) to an aerosol, then measuring and comparing the downstream concentration to the upstream concentration of the aerosol to determine the system penetration. Must be = 0.05%.

<u>Permanent HEPA (installation) filter system</u>- same as in-place HEPA system.

GLOSSARY OF ACRONYMS and INITIALS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ERDA	Energy Research and Development Administration
MIL-STD	Military Standard
RCRA	Resource Conservation and Recovery Act
UL	Underwriters Laboratory

USAEC United States Atomic Energy Commission

RESPONSIBILITIES

ES&H Section

1. Radiation Physics Technical Support Group Instrument Maintenance And Calibration (IMAC) Team

   a. Shall be responsible for the accountability, visual inspection, measuring air flow capacity and in-place leak testing of HEPA systems. These systems include permanent air filtering systems and vacuums for radioactive cleanup. The IMAC Team is not responsible for vacuums used for the cleanup of toxic or asbestos materials.

   b. Shall inform divisions/sections when systems are due for filter testing by use of the IMAC database.

   c. Shall send divisions/sections a monthly list indicating the IMAC serial number of the HEPA system that is due for testing and its location.

   d. Shall be responsible for purchasing HEPA filters, repair, replacement parts for radiological vacuums. HEPA filters or repair parts for non-radiological vacuums or in-place systems is the responsibility of the division/section using that system.

2. Radiation Physics Technical Support Group Radiation Control (RADCON) Team

   a. Shall be responsible for the cleaning and changing of filters on radiation type vacuums and any waste generated during this process.

Division/Section

1. Each division/section shall be responsible for the characterization of waste from these systems as per the Fermilab Low Level Waste Certification Plan. Some examples of waste are: the contents of a vacuum cleaner, a used HEPA filter, blasting beads from a bead blaster, etc. The Fermilab Radiological Control Manual may be used as a reference for radioactivity classification.

2. When a division/section is notified that a HEPA vacuum cleaner is due for calibration (filter testing), arrangements shall be made with IMAC team for delivery to the testing site at site 67.

3. A completed Radioactive Waste Certification And Pickup Request Form (Radiation Physics Form 31) shall accompany each vacuum.

4. The form 31 is also required after a filter from a permanent installation has been removed.

5. When a division/section is notified that a permanent HEPA installation is due for calibration (filter testing), arrangements shall be made with IMAC to access the installation at a time convenient for both parties.

6. Each division/section shall be responsible for the cost of replaceable items such as HEPA filters and parts needed for repair on non-radiological vacuums or in-place systems.

7. Vacuums used for cleanup of sodium chloride and various radionuclides, such as Business Services C.U.B. vacuum, SHALL NOT be exchanged. When the vacuum is due for calibration, it shall be processed in the following manner:
   a. The vacuum shall be transported to Site 67

   b. A RADCON member will empty the contents of the vacuum into a bag.

   c. The bag will be delivered to the division/section generating the waste for disposition.

   d. The division/section shall be notified when the vacuum is ready for pick-up after calibration.

8. Vacuums **SHALL NOT** be used for cleaning up RCRA type materials without the approval of the ES&H Technical Support Group Leader on a case by case basis.

9. Each division/section shall be responsible for changing defective HEPA filters on in-place systems.

10. The Accelerator Division shall be responsible for all testing and documentation of the in-place HEPA system located at AP-0 with the exception of the following:

    a. The leak testing shall be performed by ES&H IMAC Team.

1. The IMAC Team members testing this system shall wear as a minimum anti-contamination suit, hood, gloves, and shoe covers regardless of posting for the area. Past experience in this area brought into existence the need for this policy.

11. Each division/section shall be responsible, if needed , for testing HEPA filtered vacuums that are used for the cleanup of toxic substances, or asbestos. HEPA filter testing is not required on these vacuums, but, is required for radiation type vacuums.

12. Each division/section purchasing new HEPA systems either radiological or in-place, shall have the purchase order approved by the IMAC Team Leader prior to purchase.

13. Each division/section shall be responsible for testing, accountability, documentation, audits, and compliance with applicable standards, if the system is not approved by the IMAC Team Leader.

APPLICABLE STANDARDS

DOE Order 6430.1A
DOE ERDA 76-21
ANSI N13.6-1966(R1972)
ASME 509
ASME 510
DOD MIL-STD-282
UL 586
Fermilab Radiological Control Manual

PROGRAM DESCRIPTION

General Description

There are two basic types of HEPA filter systems used at Fermilab; permanent HEPA installations and HEPA vacuum cleaners.

1. Permanent HEPA Installations

a. Permanent HEPA installations are located at various locations on the site.

b. IMAC personnel shall perform a visual inspection, air flow capacity measurements and in-place leak testing of these systems on an annual basis. Although the configurations of each permanent HEPA installation will differ, the basic testing method will be the same.

c. Any modifications made to these systems must be approved by the IMAC Team Leader.

d. If a permanent installation fails any of the tests performed by IMAC, a division / section ES&H Group person will be notified and supplied with a failure report. The failure report will explain the failure, probable cause and suggest corrective action(s). The division / section ES&H Group shall be responsible for the corrective action(s) and any waste generated during the process. It is not IMACs responsibility to correct failures on these systems.

e. Any system which has failed any of the tests will not receive a calibration label. A tag shall be attached to the system indicating the system has failed HEPA testing. A memo shall be sent to the Senior Laboratory Safety Officer or designee, informing him that the system has failed testing and is in violation of ASME N510-1980. The Senior Laboratory Safety Officer or designee, shall meet with the appropriate division / section heads to determine the course of action to be taken on the failed system.

f. After completing the corrective action(s), IMAC will verify that the system passes all tests. After a successful completion of these tests a sticker will be affixed to each installation. The sticker will contain the date of the service, when it is again due for service, and the initials or name of the person who serviced it last.

2. HEPA Vacuum Cleaners

a. There are several brands of vacuums used at Fermilab. The standard H.E.P.A. dry vacuum cleaner is model 102ASA-9D. They are purchased from White-Pullman / Holt Products, 10702 46th St., P.O. Box 16647, Tampa, Florida 33617.

b. HEPA vacuum cleaners are broken into three separate categories, radiation vacuum cleaners (RADVAC), non-radiation toxic vacuum cleaners (TOXVAC), and asbestos vacuum cleaners (ASBVAC). Any references to HEPA vacuums where the type is not stated, indicates the HEPA vacuum is a RADVAC.

c. Only RADVAC HEPA vacuum cleaners are leak tested every 6 months by IMAC personnel. Non-radiation toxic vacuum cleaners and asbestos vacuum cleaners are the responsibilities of each division/section.

d. Each HEPA vacuum will have a sticker attached to it with the same information as mentioned in 1.e. of the permanent installation section.

e. Personnel using HEPA vacuum cleaners will be notified when their vacuum is due for service through their ES&H Group. At that time, arrangements should be made with IMAC for delivery of the vacuums.

f. Any person who believes they have a malfunctioning HEPA vacuum should call IMAC at extension 4625 for repair and replacement of the defective equipment.

g. If the possibility of leakage exists for a damaged or nonfunctional HEPA vacuum, the responsible person must put the entire vacuum in a plastic bag and inform IMAC of the problem.

h. Users should be aware that if the vacuum is equipped with a manometer and the meter exceeds 3.5" of water (indicating a clogged filter or filled canister) the unit must be returned as if it were due for maintenance. Call IMAC at extension 4625 for emptying, repair, or replacement of the equipment.

i. IMAC may assist RADCON on the repair of vacuums, if needed.

A. Radiation Type Vacuums

1. These vacuums (when due for service) shall be delivered (after prior arrangements with the IMAC team) to the vacuum storage area at Site 67.

2. Each RADVAC must include a completed Radioactive Waste Certification And Pickup Request Form (Radiation Physics Form 31).

3. At Site 67 in the vacuum emptying area, RADVACs shall have their contents removed, canister cleaned, HEPA filter inspected, etc. by an ES&H Section radiation control technician.

4. A copy of the procedure for cleaning a RADVAC shall be located in the emptying area.

5. Each RADVAC shall be:
   a. Uniquely marked and labeled

   b. Controlled by a RWP or equivalent according to the requirements of chapter 3 of the Fermilab Radiological Control Manual.

   c. Controlled to prevent unauthorized use.

   d. Designed to ensure HEPA integrity under conditions of use.

   e. Designed to prevent unauthorized or accidental access to the inner surfaces of the vacuum.

B. Non-Radiation Toxic Type Vacuums

1. These vacuums are the responsibility of the division/section using the vacuum.

2. Each TOXVAC should have their contents removed, canister cleaned, and HEPA filter inspected at 12 month intervals. More often under heavy use conditions. (*whenever the manometer exceeds 3.5" of water)*

3. The person responsible for the maintenance of this item should:
   a. Wear personal protective equipment during maintenance.

   b. Perform the maintenance in an area of containment to prevent contamination of surrounding area.

   c. Properly dispose of waste generated.

   d. Change HEPA filter every 5 years regardless of condition.

   e. Keep a record of maintenance performed for each vacuum.

   f. Have written procedures for maintenance.

4. Each TOXVAC should be:
   a. Uniquely marked and labeled

   b. Controlled to prevent unauthorized use.

c. Designed to ensure HEPA integrity under conditions of use.

d. Designed to prevent unauthorized or accidental access to the inner surfaces of the vacuum.

C. Asbestos Type Vacuums

1. These vacuums are the responsibility of the division/section using the vacuum.

2. Each ASBVAC should have their contents removed, canister cleaned, and HEPA filter inspected at 12 month intervals. More often under heavy use conditions. (*whenever the manometer exceeds 3.5" of water)*

3. The person responsible for the maintenance of this item should:
   a. Wear personal protective equipment during maintenance.

   b. Perform the maintenance in an area of containment to prevent contamination of surrounding area.

   c. Properly dispose of waste generated.

   d. Change HEPA filter every 5 years regardless of condition.

   e. Keep a record of maintenance performed for each vacuum.

   f. Have written procedures for maintenance.

4. Each ASBVAC should be:
   a. Uniquely marked and labeled

   b. Controlled to prevent unauthorized use.

   c. Designed to ensure HEPA integrity under conditions of use.

d. Designed to prevent unauthorized or accidental access to the inner surfaces of the vacuum.

3. HEPA Filters

a. All HEPA filters used in vacuums shall be nuclear grade for filtration of radioactive dust, asbestos dust, bacteria, micro-organisms and other hazardous toxic airborne dusts and materials.

b. All HEPA filters used in permanent installations shall be nuclear grade for filtration of radioactive dust.

c. All HEPA filters shall be 99.97% efficient at 0.3 micrometers, based on DOP test MIL-STD-282*. Approved UL class 1. Constructed under MIL-F-51068. Meets the requirements of the USAEC Regulatory Guide 1.52. *(* see Technical Appendix, Fermilab Deviations From Applicable Standards)*

d. Vacuum HEPA filters are ordered from White-Pullman / Holt Products part number B160009. An equivalent replacement filter may be used if it is appropriate for the vacuum and meets the specifications in 3.a. and 3.c.

e. When HEPA filters are received from the manufacturer for either permanent or vacuum systems, the following shall be performed:

   1. Each box containing a HEPA filter must be labeled with the date the filter was received and an expiration date 10 years beyond the received date. *The effect of long term storage of HEPA filters is not well understood, however, since the possibility of degradation exists; Fermilab will not store HEPA filters for any length of time greater then ten years.*

   2. Verify that the storage of these filters are in an orientation such that the pleats of the HEPA filter are in a vertical position. *A storage position of horizontal may cause pleats to sag and separate and in turn cause holes in the filter medium.*

TECHNICAL APPENDIX - HEPA FILTER SYSTEM PROGRAM

FERMILAB DEVIATIONS FROM APPLICABLE STANDARDS

ANSI N510

1. ANSI N510 section 10.4.1 states that in-place of HEPA filter banks shall be tested using Di (2-ethylhexyl) phthalate (DOP) aerosol. Fermilab does not and will not use this substance for the following reasons:

    a. DOP is a known carcinogen.

    b. Westinghouse Hanford Company, Fermilab's waste disposal facility will not accept HEPA filters that have been tested with DOP as Radioactive waste. Fermilab personnel attended a workshop on In-Place Filter Testing in June 1993. One of the topics discussed was the use of alternative liquids in Laskin nozzle generated aerosols for filter testing. The conclusion indicated that other liquids can be used as long as adjustments or calculations are made to test instrumentation to compensate for the different liquids used. Emery 3004 a synthetic aliphatic hydrocarbon is the recommended replacement. Fermilab shall use Emery 3004 as aerosol replacement for DOP.

2. ANSI N510 section 12 is an in-place test of adsorber stage. This test confirms the adsorbing capabilities of the activated carbon charcoal filter. Fermilab will not perform this test for the following reasons.

    a. The tracer gas used in this test is Freon and can not be used because it depletes the ozone layer.

    b. Fermilab is not a nuclear power reactor. The purpose of an adsorber stage in HEPA systems is for the adsorbtion of Iodine 131 which is produced during the burn-up of nuclear fuel. Since Fermilab is not a reactor and through process knowledge does not produce Iodine 131 in it's accelerator, this test will not be performed. This also includes ANSI N510 section 13, Laboratory Testing Of Adsorbent.

3. ANSI N510 section 3.13 defines a HEPA Filter as being a fibrous medium which produces a particle removal efficiency of at least 99.97% for 0.3 micrometer particles of DOP when tested in accordance with

MIL-STD-282. Fermilab reserves the right to purchase HEPA filters which are not tested in accord with MIL-STD-282. The justification for not following MIL-STD-282 is that there is a requirement to test using DOP causing the problem of mix waste when a filter is disposed of. A solution to the problem is that Fermilab may specify that filters be tested in accord with MIL-STD-282 with the exception of the efficiency test. The efficiency test will done using another "safe" aerosol or be tested using a laser photometer and ambient air particles.

CALCULATIONS USED IN THE HEPA PROGRAM

	d=	Duct Diameter	
	d ft.=	inches / 12	
	A=	Duct Area	$=p\,(d/2)^2$
	VP=	Velocity Pressure (inches of water)	
	V=	Velocity (fpm)	$=4005v\ VP$
	V_{avg}=	Average Velocity	$=(V_1+V_2+V_3+...V_{10})/10$
	h=	Flow meters Manometer (inches of water)	
	Q=	Air Flow (cfm)	$=V_{avg}A$
Orifice Eq:	Q=	Kv h	
or	K=	constant for a particular meter	=Q / v h
	µg / L=	mg/m^3	
	one cfm=	28.3 L / min.	

One Laskin nozzle at 20 psi discharges 75L / min of air containing 5.1 mg / L of DOP.

5.1mg / L x 75L / min x 1000µg / mg = 382,500µg / min

$$CDOP = \frac{\text{number of Laskin nozzles}}{\text{air flow through filters (cfm)}} \times \frac{382{,}500}{28.3}$$

or

$$CDOP = \frac{\text{number of Laskin nozzles}}{\text{air flow through filters (cfm)}} \times 13{,}500$$

TEST EQUIPMENT

Aerosol Generators

1. A Laskin type aerosol generator is used as a challenge for HEPA systems with flow rates less than 500 CFM. The instrument used is an Air Techniques Incorporated model TDA-6A.

Low Flow Aerosol Generator

   a. Specifications:

      1. Better than 99% of the particle sizes produced are less than 3.0 micrometers. 95% less than 1.5 micrometers, 92% less than 1.0 micrometers, 50% less than 0.72 micrometers, 25% less than 0.45 micrometers, 10% less than 0.35 micrometers.

      2. It is a self contained unit that operates on 110 volts AC and has a capacity for systems up to 500 CFM.

      3. It requires no adjustments and there are no controls except the on-off switch.

      4. The continuous duty compressor operates two Laskin-type nozzles and the oversized reservoir has the capacity to operate for hours without refilling.

      5. Although this piece of equipment is designed to generate an aerosol using Di (2-ethylhexyl) phthalate (DOP), Fermilab specified that Emery 3004 be used as the liquid aerosol generating agent. This instrument is calibrated by the manufacture to produce the same characteristics as DOP.

6. Applicable specifications and standards are:

   A. U.S. Federal Standard 209b, paragraph 50.

   B. American Association of Contamination Control standards CS-1T, CS-2T and CS-6T.

   C. American National Standards Institute N101.1-1972.

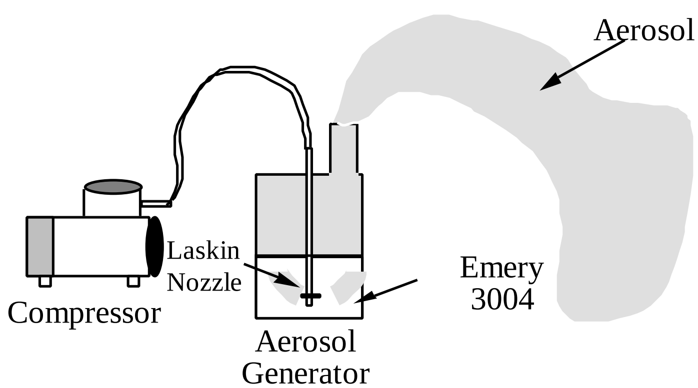
   D. ANSI/ASME N510-1980.

   E. Institute of Environmental Sciences IES-RP-CC-001 & 002-86.

b. Theory of Operation:

1. The TDA-6A produces an aerosol by passing clean self compressed air through a Laskin nozzle which is submerged in a reservoir of liquid (EMERY 3004). The Laskin nozzle create a liquid aerosol of consistent particle size distribution by shearing the liquid with air. The aerosol concentration depends on the compressed air pressure applied to the Laskin nozzle. One Laskin nozzle at 20 psi discharges 75L/min of air containing 5.1 mg/L of aerosol. When this aerosol is diluted with 135 cfm of air, the aerosol concentration becomes approximately 100 micrograms per liter using the following formula:

$$\text{Concentration} = \frac{\text{number of Laskin nozzles}}{\text{air flow through filters (cfm)}} \times \frac{382{,}500}{28.3}$$



c. Comments:

2. It is believed that Air Techniques Incorporation improperly specified their TDA-6A as having the capacity to be used on

systems up to 500 CFM. Using the formula above and replacing the variables with numbers, we can see that this instrument does not produce the recommended 100 µgrams/Liter for HEPA filter testing. We also assume that the air compressor is 20psi.

$$\text{(Concentration) } 54 = \frac{2 \quad \text{(nozzles)}}{500 \quad \text{(cfm)}} \text{ X } \frac{382{,}500}{28.3}$$

However, since the vacuum systems being tested have flow rates of 135 CFM this generator is more than adequate.

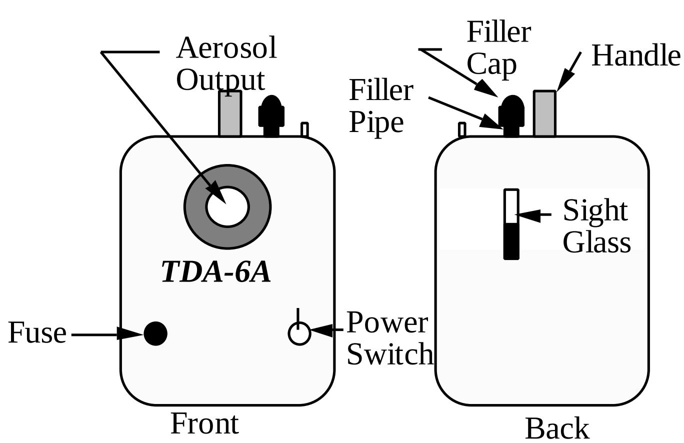
d. Operation:

1. Check sight glass of the aerosol generator. It is located in the back of the generator. Confirm that unit is half-full with EMERY 3004. O.K. *(go to step d.3)* No. *(go to next step)*

2. If it is empty or not half-full then unscrew the finger tight filler cap. Locate EMERY 3004 in five gallon can. Remove cover from EMERY 3004 can and pour contents into filler pipe of generator until sight glass shows half-full. Replace cover from EMERY 3004 can and filler cap.

3. Move Aerosol Generator system to be tested. Connect a vacuum hose from the aerosol generator to the system under test challenge port.

4. Plug generator line cord to an appropriate power source. Turn power switch **ON**. *CAUTION*: Do not tilt unit more that 30 degrees from the horizontal after the generator is filled to prevent EMERY 3004 from leaking out of the reservoir.



2. A thermal type aerosol generator used as a challenge for HEPA systems with flow rates larger than 500 CFM. The instrument used is an Air Techniques Incorporated model TDA-5A.

Thermal Type Aerosol Generator

a. Specifications:

1. Better than 99% of the particle sizes produced are less than 3.0 micrometers. 95% less than 1.5 micrometers, 92% less than 1.0 micrometer, 50% less than 0.7 micrometers, 25% less than 0.45 micrometers, 10% less than 0.4 micrometers.

2. The instrument operates on 110 volts AC and requires compressed nitrogen gas 50psi input at 15 scfh. It is capable of producing 100µg/L of DOP when diluted with 7500 CFM of air.

3. Although this piece of equipment is designed to generate an aerosol using Di (2-ethylhexyl) phthalate (DOP), Fermilab specified that Emery 3004 be used as the liquid aerosol generating agent. This instrument is calibrated by the manufacture to produce the same characteristics as DOP.

4. Applicable specifications and standards are:

A. U.S. Federal Standard 209b, paragraph 50.

B. American Association of Contamination Control standards CS-1T, CS-2T and CS-6T.

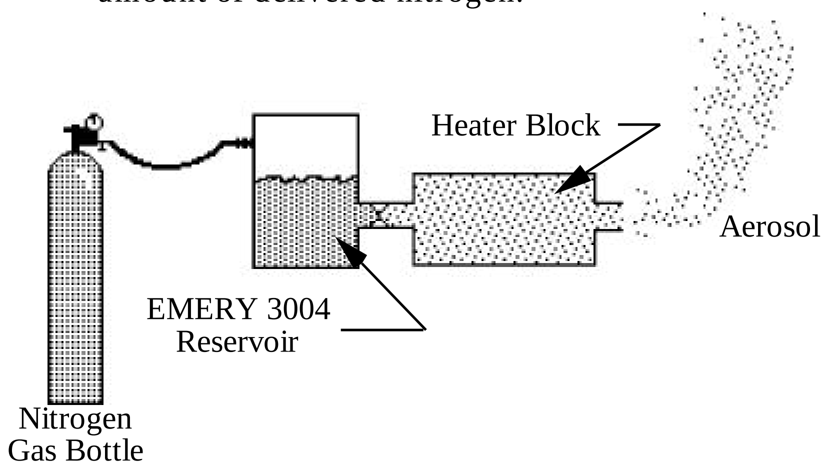
C. American National Standards Institute N101.1-1972.

D. ANSI/ASME N510-1980.

E. Institute of Environmental Sciences IES-RP-CC-001 & 002-86.

b. Theory of Operation:

1. Aerosol of consistent particle size distribution is created by discharging a regulated quantity of EMERY 3004 liquid onto a large heated area. The EMERY 3004 is vaporized and reconstituted into a polydispersed aerosol by a small amount of delivered nitrogen.



c. Operation:

1. Check sight glass of the thermal aerosol generator. It is located in the back of the generator. Confirm that unit is half-full with EMERY 3004. O.K. *(go to step c.3)* No. *(go to next step)*

2. If it is empty or not half-full then unscrew the finger tight filler cap. Locate EMERY 3004 in five gallon can. Remove cover from EMERY 3004 can and pour contents into filler pipe of generator until sight glass shows half-full. Replace cover from EMERY 3004 can and filler cap

3. Move Aerosol Generator system to be tested. Connect a vacuum hose from the aerosol generator to the system under test challenge port.

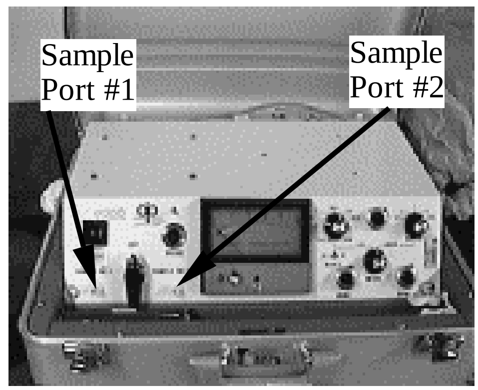
4. Plug generator line cord to an appropriate power source. Turn power switch **ON**. *CAUTION*: This device generates heat. Do not tilt unit more that 30 degrees from the horizontal after the generator is filled to prevent EMERY 3004 from leaking out of the reservoir.

5. Connect nitrogen gas bottle to Aerosol Generator. Set the gas bottle regulator to 20 psi. Allow 15 minutes for the generator to heat up. A lamp will light indicating the generator is ready for operation.

Photometer

1. The photometer used is a Virtis Company JM-8000 Aerosol Dust and Smoke Photometer.

Photometer



a. Specifications:

1. It is capable of measuring particles from 0.0001 to 100 ^{ug} /L for all significant airborne particles.

2. The instrument contains two valved ports that sample at a rate of 1 liter per minute.

3. The dark current of the instrument is zeroed out and the gain is adjusted for each calibration performed.

4. The reading of the photometer depends on particle size, shape, refractive index and size heterodispersity. Exact concentration measurements of EMERY 3004 is not possible by this instrument. However, relative measurements are, which is the method used in this program.

5. This instrument is factory calibrated annually.

6. Applicable specifications and standards are:

A. U.S. Federal Standard 209b.

B. American Association of Contamination Control standards CS-1T, CS-2T and CS-6T.

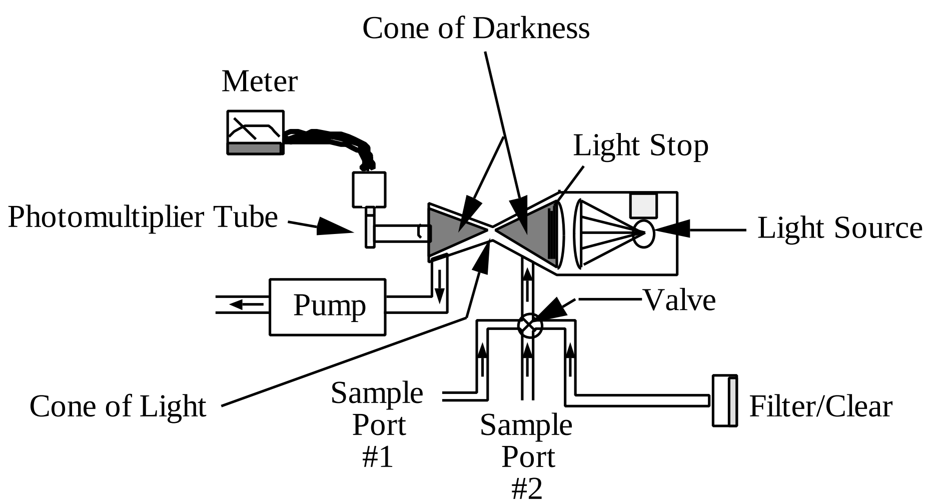
C. American National Standards Institute N101.1-1972.

D. ANSI/ASME N510-1980.

E. National Sanitation Foundation Standard No. 49

b. Theory of Operation:

1. A built-in vacuum pump draws the sample atmosphere through a very small detection area located in the optical chamber assembly. Particles in the sample scatter light from the intense focused beam onto a photomultiplier detector. The amount of light scattered is related to the mass concentration of the particles present.



c. Operation:

1. Initial warm-up of photometer. Open the carrying case to display the instrument. Make sure all switches are in the off position.

2. Set the **Zero** adjustment to 10 clockwise and the **Span** control to 0 counter -clockwise. Plug in line cord to an appropriate power source.

3. Turn the **Log-Linear** Mode switch to its **Linear** position and rotate the **Range** switch to **100**.

4. Turn the power on via the illuminated push-button **Power** switch. Allow approximately 90 seconds for the **Calibration** lamp to illuminate.

5. Connect one end of a piece of tubing to **Sample No. 1** and the other side to the upstream sample port of the system under test. Connect another piece of tubing to **Sample No. 2** and the other side to the upstream sample port of the system under test. These pieces of tubing must be the same length.

6. Start the blower on the system under test and then start the aerosol generator.

7. Switch the sample valve to **Sample No. 1**.

8. Adjust the span control clockwise until a full scale reading is obtained on the panel meter; then set the sample valve to clear. Wait for the chamber to purge itself of the test aerosol, then rotate the **Range** switch to the **.1%** position.

9. Adjust the **Zero** control (counter-clockwise) to obtain a reading of "0" on the instrument panel meter. Turn the **Range** switch to the **.01% Range**. Adjust the zero control to obtain a reading of "0" on the instrument panel meter.

10. Return the **Range** switch to **100** and switch the sample valve to **Sample No. 1**; a reading of "100" should appear on the panel meter. If it does not, repeat steps c.8 and c.9 until an exact full scale and zero readings are obtained.

11. The instrument is now set to directly measure the penetration of any filtration system. By selecting sample **No. 1** *the upstream sample* or **No. 2** *the downstream sample* and proper selection of the **Range** control, a direct penetration is obtained. Example: If the meter reading is 1/2 of full scale on the 0.1% range when sampling on the downstream (**No. 2** sample port) side of the filter, then the system penetration is 0.05% and overall efficiency is 99.95%. Record the meter reading and calculate the penetration and system filter efficiency.

    ____________ meter reading on the 0.1% range *must be <50*

    ____________ system penetration *meter reading above/1000*

____________ system efficiency *100-system penetration*

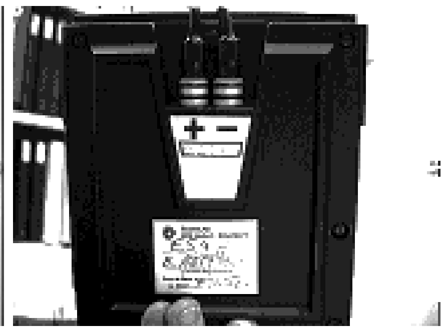
If the system penetration is greater than 0.05%, the person responsible for the system must be notified and will be expected to change and dispose of the defective HEPA filter or other part. An entirely new worksheet must be used after the replacement of a new filter or part.

Velometer

1. The velometer used is an Alnor series 6000.

Velometer (Front)

Velometer (Rear)



a. Specifications:

1. Velocity ±2% of full scale.

A. Ranges are from 0 to 10,000 feet per minute.

2. Static pressure ±5% of full scale.

A. Ranges are from 0 to 10. inches of water.

3. This instrument is factory calibrated annually.

b. Theory of Operation:

1. The velometer set consists of a meter, velocity and static pressure range selectors, measuring probes and connecting hoses.

2. The meter is the nerve center of the velometer set. It receives the sensing signal from the various probes and translates it to a velocity or static pressure depending on the range selector setting.

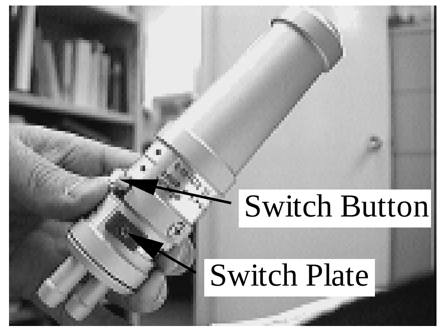
c. Operation:

1. The velometer set consists of a meter, velocity and static pressure range selectors, measuring probes and connecting hoses.

2. Remove sensing port caps.

3. Connect two hoses to sensing ports.

Range Selector



4. Select proper range selector.
   A. For velocities below 2500 feet per minute or static pressures below 1” of water, use the range selector with the black letters.

   B. For velocities above 2500 feet per minute or static pressures above 1” of water, use the range selector with the red letters.

   C. A range selector is not used with the lo-flow probe at velocities below 300 feet per minute.

5. Connect the hoses to the range selector as follows:

   A. Connect the (+) sensing port of the meter to the (+) sensing port of the range selector. Connect the (-) sensing port of the meter to the (-) sensing port of the range selector. This configuration is used for positive pressure and supply flow rate measurements.

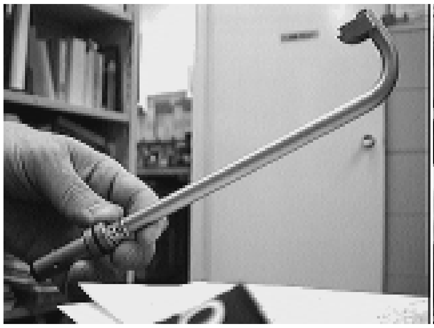
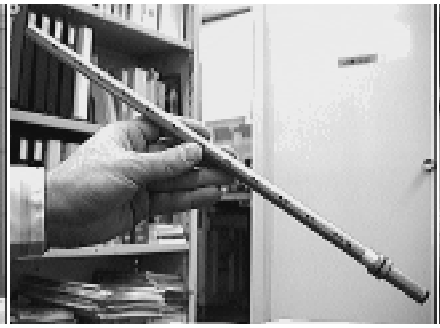
   B. Connect the (+) sensing port of the meter to the (-) sensing port of the range selector. Connect the (-) sensing port of the meter to the (+) sensing port of the range selector. This configuration is used for negative pressure and return or exhaust flow rate measurements.

6. Insert a probe into the range selector. Push the probe firmly down until the collar of the probe rests against the top of the range selector.

7. Check the position of the switch button on the range selector. It must be pushed in and turned to latch it in when using the diffuser or static pressure probe. It must be released and left in the out position when using the pitot probe.

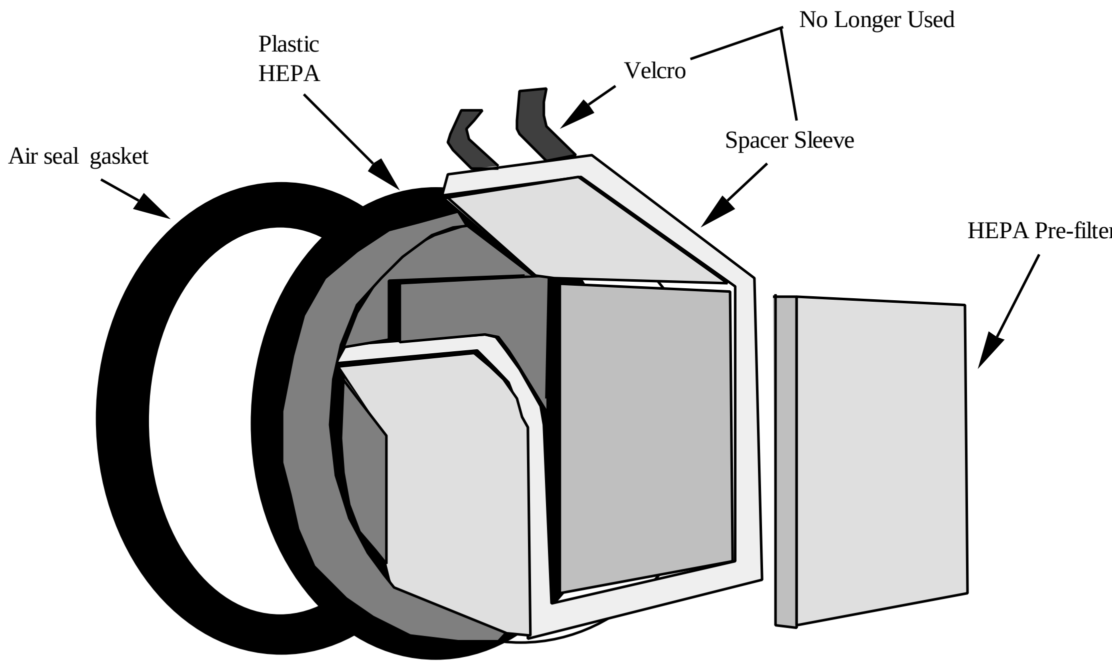
8. Check position of the switch plate on the range selector. It must be positioned for the proper velocity range.

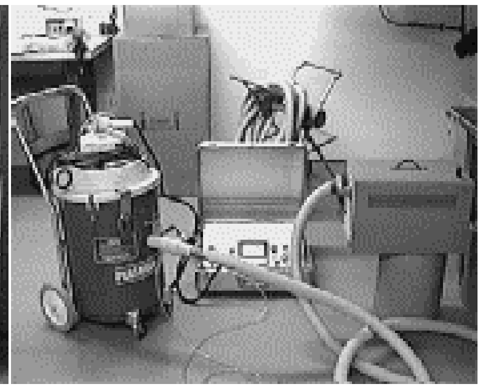
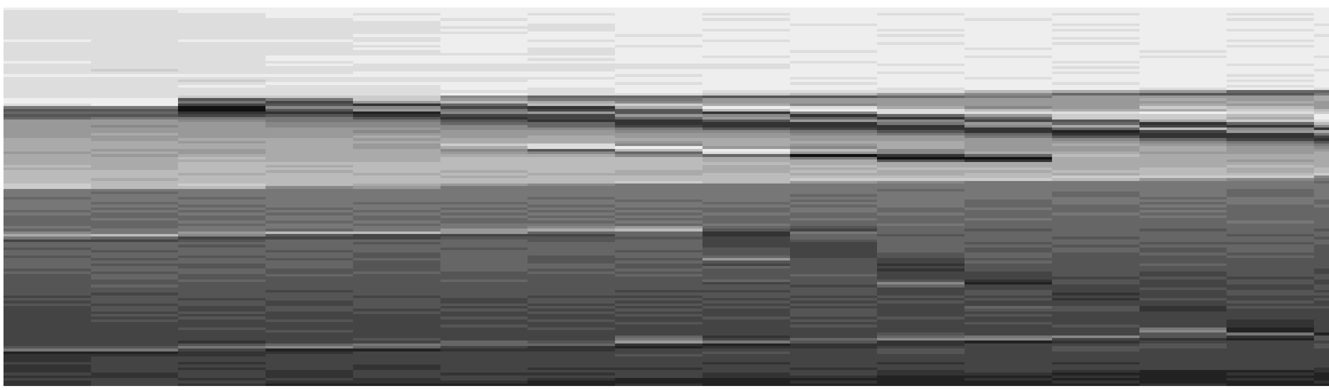
9. Make measurements.

Reference Pictures

6070P Velocity Probe

6060P Pitot Probe

6080 AP/CP Static Pres. Probe

Vacuum Cleaner HEPA Filter



RADVAC HEPA Filter

RADVAC under test